IERS Conventions Implementation Issues

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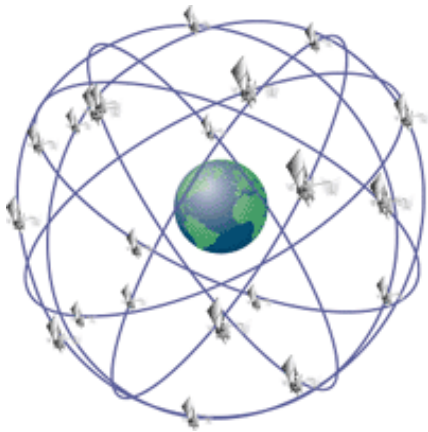
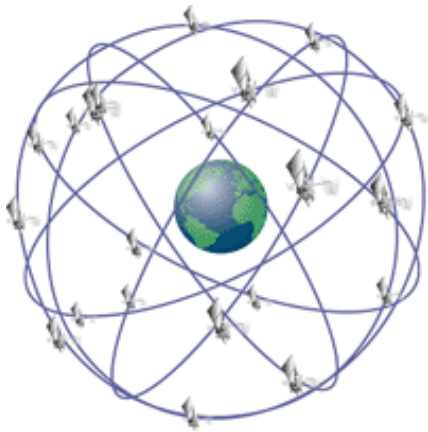
Overview

- Last 2 years at ESOC all IERS 2003 models implemented for GNSS, SLR, and DORIS.
  - New CRF/TRF transformation, Solid tides, Ocean tides, Ocean tidal loading, etc. etc.
  - Sometimes software available sometimes not
    - » Documentation of available software
    - » Quality of available software
- Software comparisons between AIUB, GFZ, and ESOC in the framework of the Galileo Geodetic Service Provider
  - CRF/TRF transformation
  - CMC correction
  - Orbit Integration

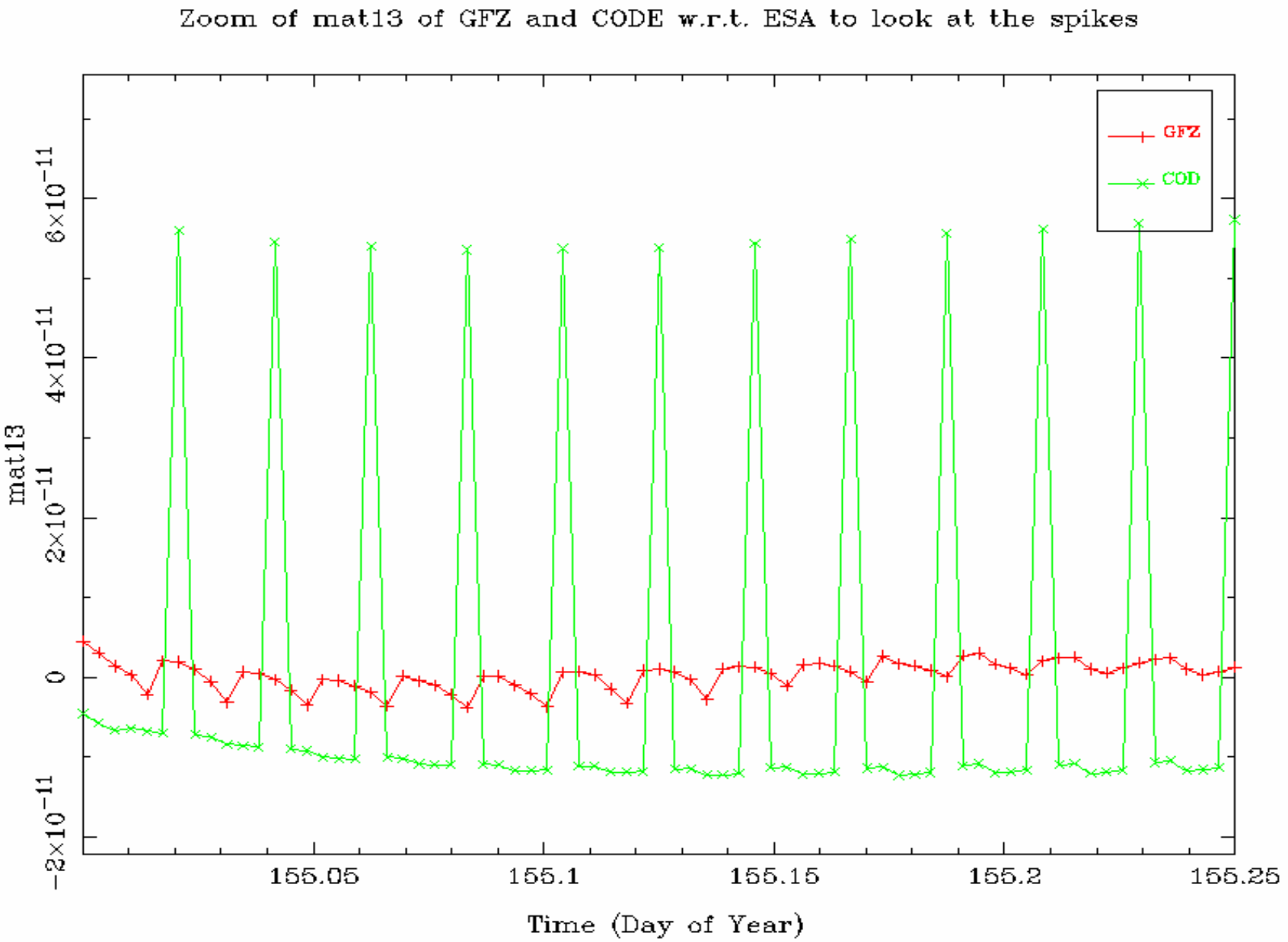


TRF/CRF Transformation

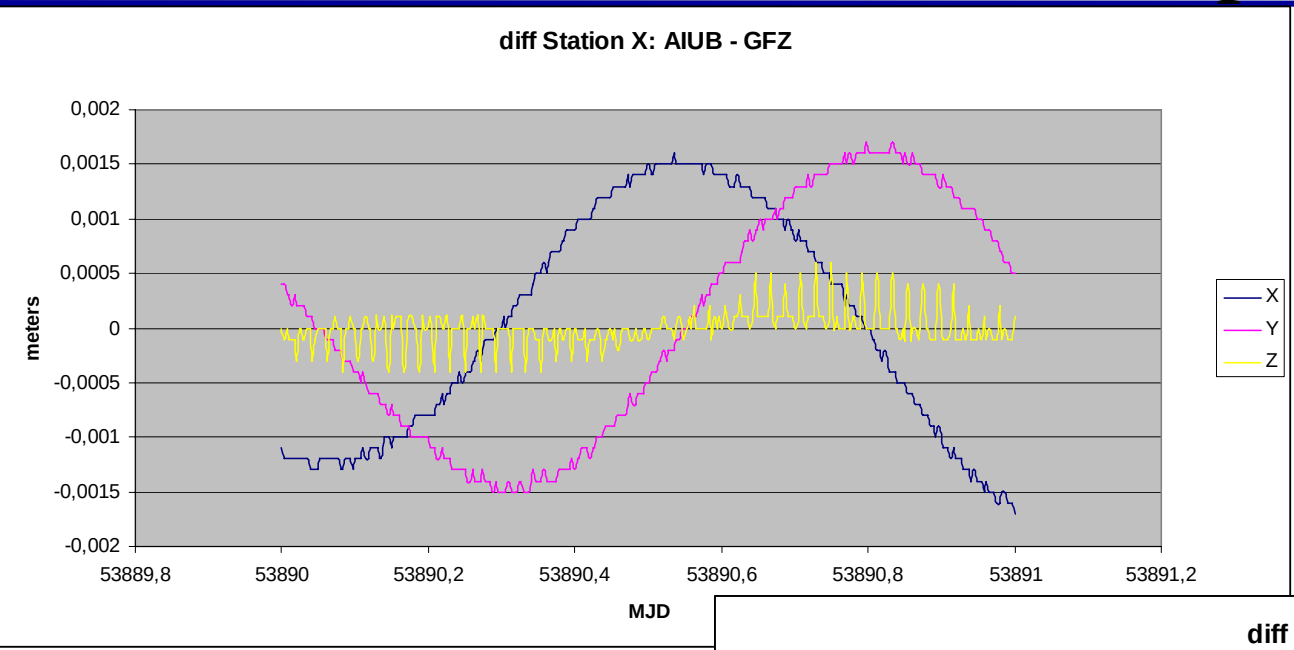
- IERS TRF/CRF software quality is OK.
  - Has documentation
  - Uses “implicit none”
  - Unfortunate that two different notations exist (dpsi/deps vs dX/dY)
    - » At least three different implementation scenarios
  - And….the software is very CPU demanding
  - This causes “special” handling at the ACs
    - » Buffering, interpolation, etc. etc.
  - These implementations have to be tested
    - » Not always easy.

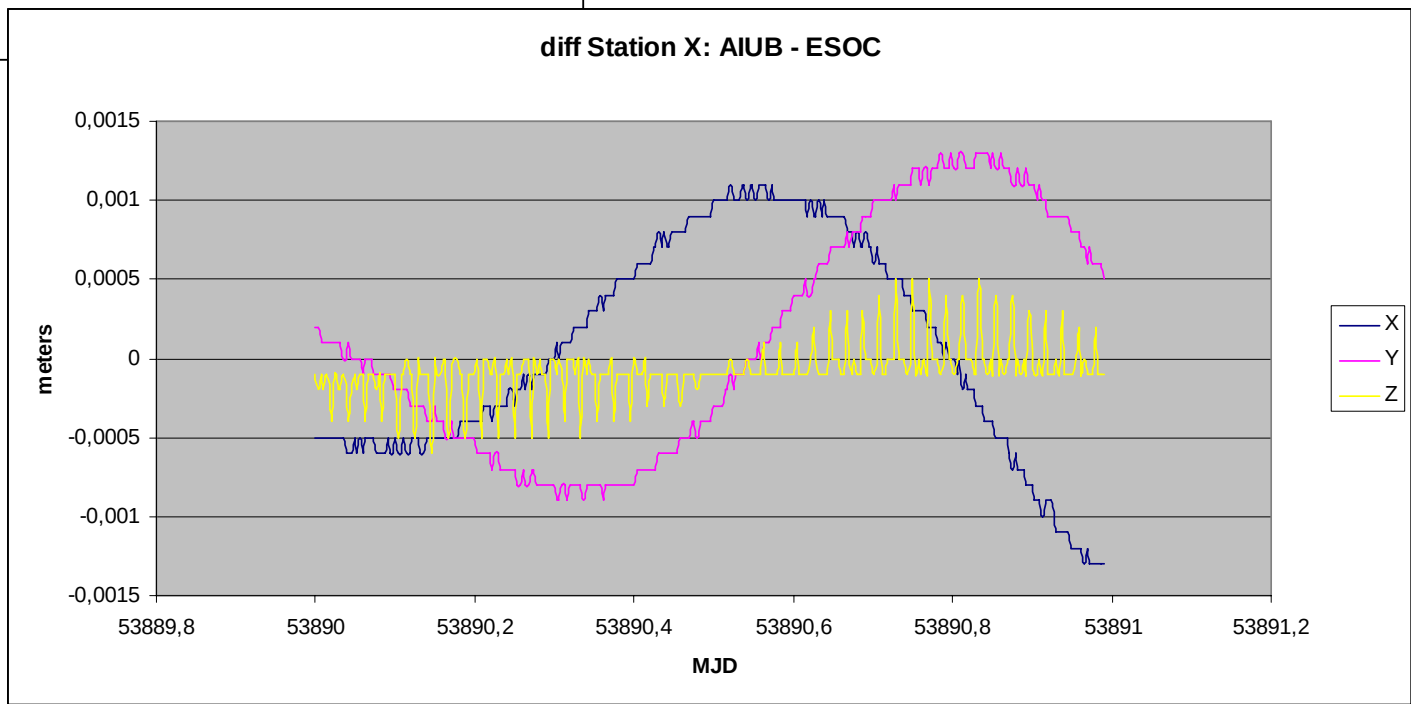


CRF/TRF Interpolation



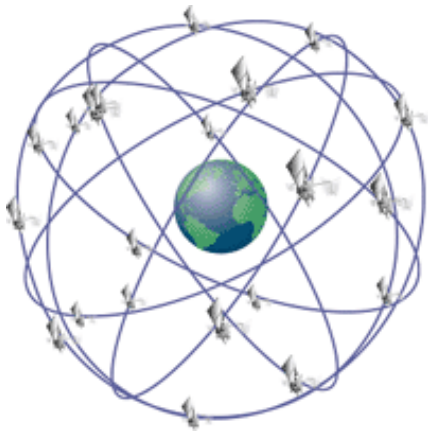
CRF/TRF Interpolation





CMC Correction

- Ocean tidal loading coefficients can be using including or excluding the CMC correction
  - For orbit estimation the CMC correction should be taken into account
  - IGS products are crust based and therefore CMC effect should be “removed” from the orbits
- Ocean tidal loading effects applied using the “hardisp” subroutine
  - This means that also the CMC correction should be applied using the hardisp subroutine.
  - All three ACs used the “classical” (11 constituents) computation to compute the effect of the CMC correction.
    - » Causing discrepancy between computing ocean tidal loading based on coefficient including the CMC effect and coefficients not including the CMC effect but adding the CMC effect separately.
    - » The differences were of equal size as the CMC correction itself!
- Furthermore “hardisp” software has/had several problems
  - Sign error
  - Variable “initial” mistyped as “intial”
  - Long periodic terms still questioned.

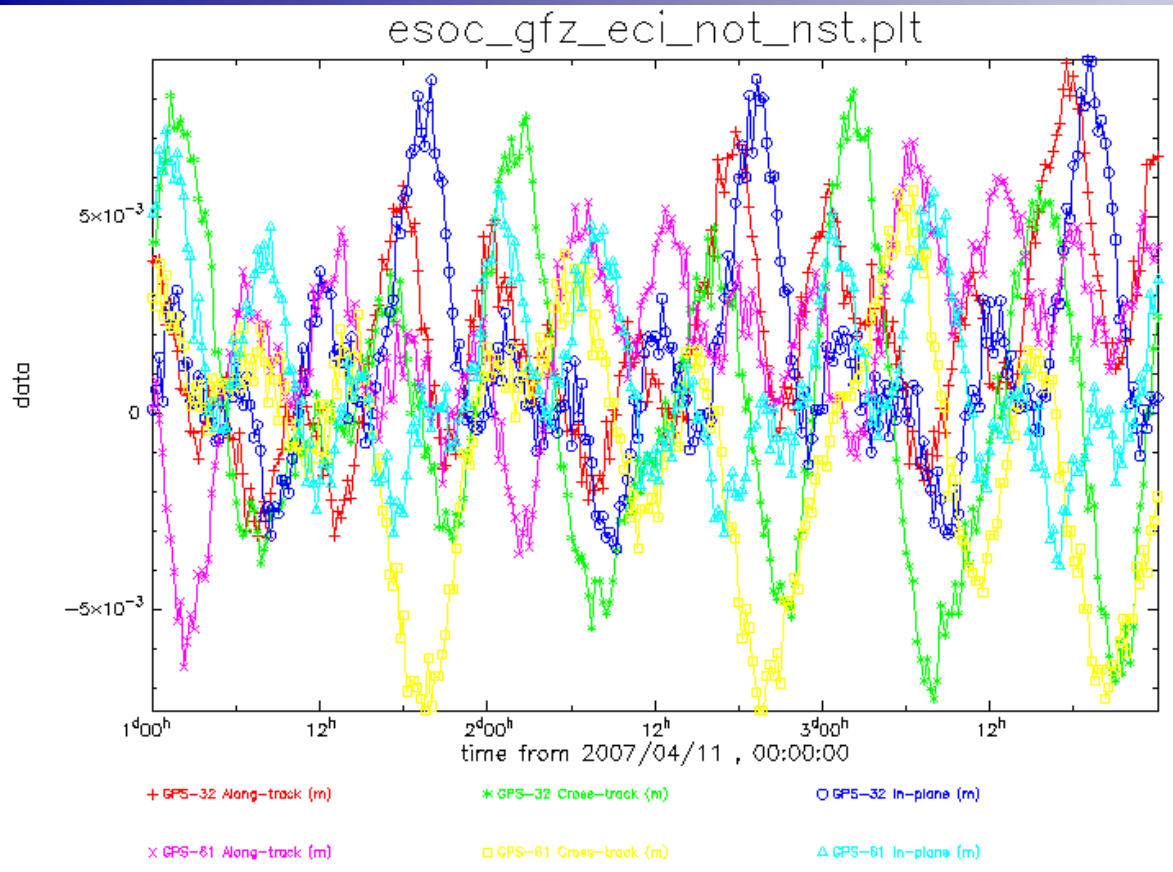


Initial Orbit Integration Differences (ECF)

PRN 01 (eclipse)	RMS orbit differences over 3-days (mm)			
	Radial	Along	Cross	Total
AIUB - ESOC	**19**	**285**	**32**	**287**
AIUB - GFZ	**44**	**123**	**57**	**143**
ESOC - GFZ	**30**	**242**	**51**	**249**
PRN 02	Radial	Along	Cross	Total
AIUB - ESOC	**6**	**37**	**44**	**58**
AIUB - GFZ	**17**	**216**	**57**	**273**
ESOC - GFZ	**16**	**244**	**59**	**251**

Current Orbit Integration Differences (ECI)

	PRN01 RMS orbit (mm)				PRN02 RMS orbit (mm)			
ECI WOT	Radial	Along	Cross	Total	Radial	Along	Cross	Total
AIUB - ESOC	**19**	**88**	**8**	**91**	**6**	**66**	**6**	**66**
AIUB - GFZ	**45**	**149**	**22**	**157**	**17**	**242**	**34**	**245**
ESOC - GFZ	**28**	**100**	**19**	**106**	**18**	**303**	**31**	**305**
ECI NOT								
AIUB - ESOC	**18**	**56**	**7**	**59**	**6**	**13**	**8**	**16**
AIUB - GFZ	**18**	**56**	**5**	**59**	**5**	**12**	**6**	**15**
ESOC - GFZ	**3**	**2**	**4**	**6**	**3**	**2**	**3**	**5**
ECI NOT NST								
AIUB - ESOC	**18**	**56**	**4**	**59**	**5**	**16**	**6**	**18**
AIUB - GFZ	**18**	**57**	**3**	**60**	**5**	**17**	**3**	**18**
ESOC - GFZ	**3**	**3**	**4**	**6**	**3**	**3**	**3**	**5**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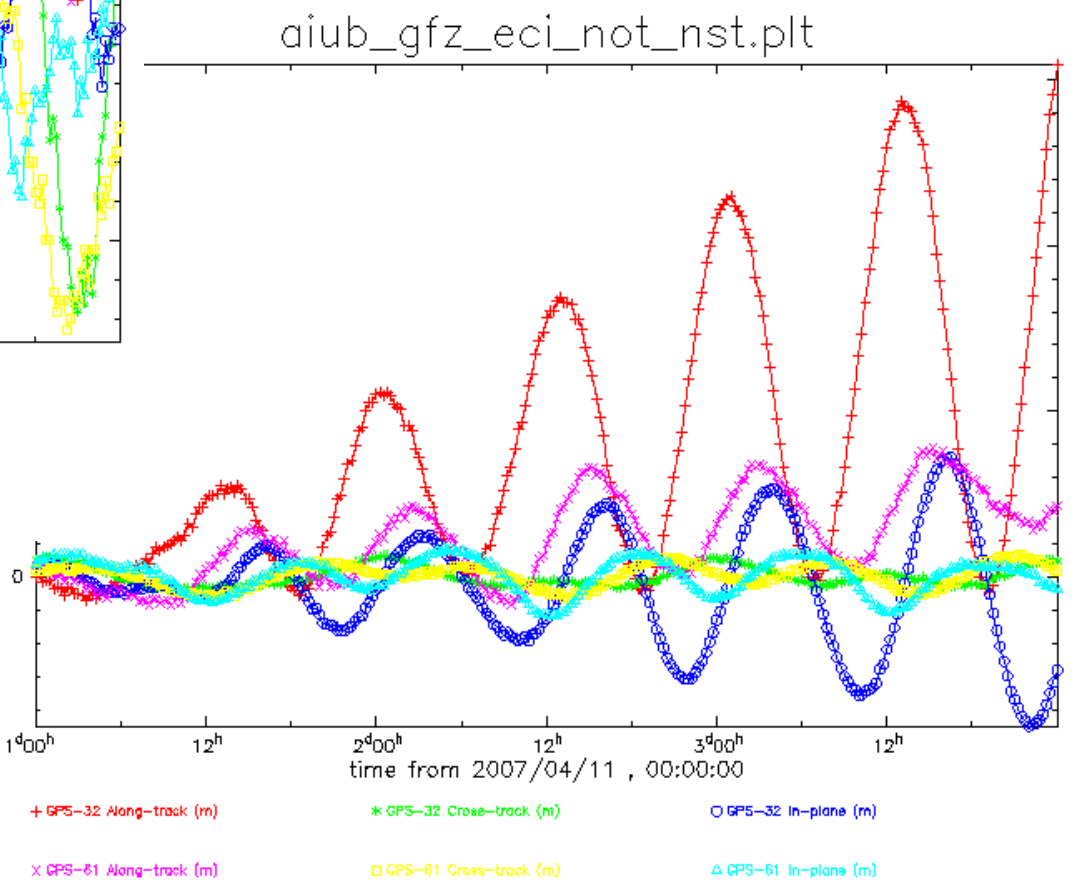
data
5×10⁻³
0
−5×10⁻³
1d00h
12h
2d00h
12h
3d00h
12h
time from 2007/04/11 , 00:00:00
+ GPS-32 Along-track (m)
* GPS-32 Cross-track (m)
○ GPS-32 In-plane (m)
× GPS-61 Along-track (m)
□ GPS-61 Cross-track (m)
△ GPS-61 In-plane (m)


aiub_gfz_eci_not_nst.plt
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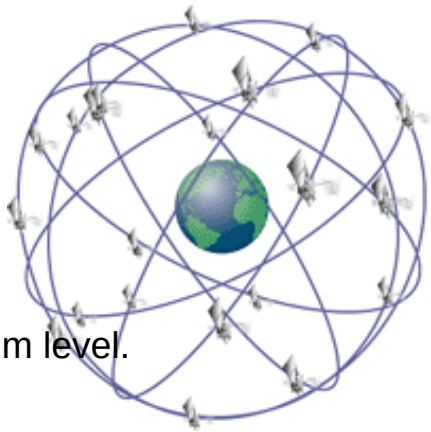
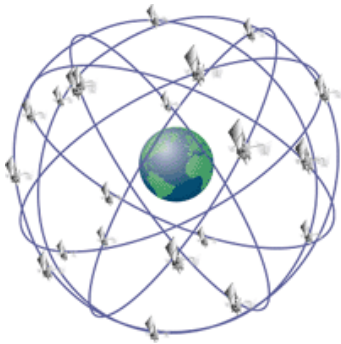
Orbit Integration



- Results still at the hundreds of millimetres!
  - Much worse then expected; GPS uses a simple model
  - Main problems with Ocean Tides; Without Ocean Tides problems are at the 60 mm level.
- Identified problems
  - ESOC Solid Tides implementation (corrected)
  - ECI-ECF transformation problem between ESOC and GFZ.
    - » Z-rotation of 0.25 mas.
  - AIUB ECI-ECF transformation seems to have UT1-UT1R correction disabled.
  - Ocean Tides model of GFZ outdated
  - Ocean Tides implementations at AIUB and ESOC also significantly different.
    - » Most likely caused by usage of different “cut-offs” regarding the used constituents. Should be investigated.
- Unidentified problem
  - AIUB 60 mm difference compared to GFZ and ESOC for PRN01, even with Ocean and Solid tides turned off.
    - » Relativistic effects, Eclipse “tricks”?

Discussion Points (1/2)

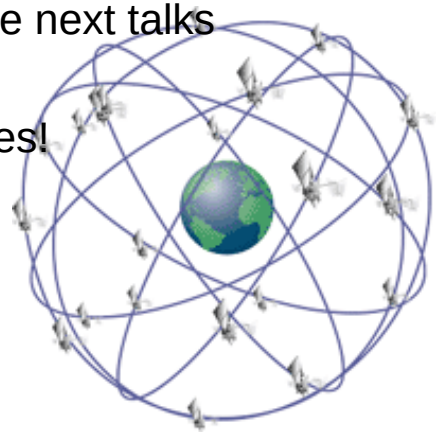
- IERS conventions “internal consistency”
  - FES2004 Ocean Tidal loading but no FES2004 ocean tides for gravity field effect (at least not publicly available)
    - » Should a model be accepted if it is only “partial”, e.g., new ocean tides for station movement but not for gravity.
- IERS conventions software
  - Needs some minimal standards
    - » Use of “IMPLICIT NONE”
    - » A “readme” describing clearly the input and outputs
      - Some routines say MJD as input time. MJD is a time format not a time system!
    - » Some routines do not work beyond 2006 but print a warning…..which may fill your disk!
      - Solid tides subroutine. Also wrong by one month for leap seconds
      - Software should be valid for the next 5 years. If not this should be clearly documented and not just a “warning” message.
  - Each software should come with a set of “reference” results
    - » So that ACs can verify/validate their implementation
    - » So that other experts can study if the selected/provided software is correct



Who and how to handle this within the IERS

Discussion Points (2/2)

- Current level of agreement between IGS ACs is quite poor! Even between two very good ones!!
- We need software tests and validation between the different ACs
  - Seems that ILRS already does this (very good, interested in hearing the next talks on this)
  - Need this for all services (IDS, IGS, and IVS) but also across techniques!
    - » E.g. for troposphere, LEO orbit modelling, etc. etc.!
  - CPU intensive routines are treated in different ways by different ACs
    - » Same CRF/TRF routines give very different answers!
    - » These differences have to be understood, verified, and validated.
      - E.g. “Cut-off” level for ocean tides effect on gravity
- Handle IERS conventions “ambiguity”
  - Often there is more than one convention for a certain model (elastic vs unelastic)



Can and should be handled with the techniques (IDS, IGS, ILRS, IVS)!
How to handle across techniques?